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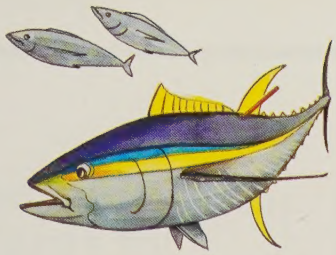

Pelagic Fisheries Research Program

university of hawai'i at mānoa

Volume 11, Number 1

January–March 2006

Behavior of Bigeye and Skipjack Tunas Within Large Multi-Species Aggregations Associated with Floating Objects

Kurt Schaefer and Daniel Fuller

Schools of tuna within large multi-species aggregations associated with moored and drifting fish-aggregating devices (FADs) have been commercially exploited since the early 1990s by the tuna purse-seine vessels in the eastern Pacific Ocean (EPO). Since then this practice has escalated between 5°N and 15°S, from the coast of the Americas to 150°W. This has resulted in a dramatic increase in the catch of bigeye (*Thunnus obesus*) by the EPO surface fishery, although the greatest component of the catch of the FAD fishery is skipjack tuna (*Katsuwonus pelamis*). Justifiable concerns with FAD fishing include overexploitation of juvenile bigeye tuna and discards of unmarketable tunas and other species.

The Inter-American Tropical Tuna Commission (IATTC) initiated a large-scale bigeye tuna tagging project in the equatorial EPO in 2000 in order to improve the scientific basis for estimation of the movements, fishing and natural mortality rates, and growth of these species. Since 2000, the numbers of bigeye and skipjack tagged in this project with conventional plastic dart tags are 19,150 and 2,792, and archival (data storage) tags 319 and 131, respectively. A secondary objective of the project is to investigate the fine-scale spatial and temporal dynamics of bigeye and skipjack tunas concurrently within large multi-species aggregations associated with moored and drifting floating objects, hundreds of miles from land in areas of large-scale tuna purse-seine fisheries, using ultrasonic transmitters (henceforth referred to as acoustic tags) coupled with sonar imaging.

Field studies were conducted in close proximity to two Tropical Atmosphere-Ocean (TAO) moorings at 2°S-95°W and 2°N-95°W in May 2002 and May 2003, respectively, utilizing the chartered MV *Her Grace*, a live-bait pole-and-line vessel. The approximate depths of the seafloor at the 2°S and the 2°N TAO moorings are 3,438 m and 3,091 m, respectively. The ultrasonic telemetry studies consisted of passive monitoring of tunas within aggregations, rather than active tracking of individual tunas. For the telemetry studies in 2002 and 2003, the vessel remained moored within 20 m of the buoy, with the main engine off, so as to not create acoustical interference or influence the behavior of the tuna aggregations (Figure 1). In 2003, the vessel drifted away from the TAO buoy with the aggregation associated with the vessel in order to evaluate changes in tuna behavior between a moored and drifting floating object.

Figure 1. Orientation of aggregation associated with the moored buoy. The current direction is indicated by the arrow. Triangle indicates direction of V-fin and bow hydrophone.

Telemetry was conducted using a Vemco VR-28 monitoring system, containing four separate receivers, in conjunction with a Vemco V-41 (28-50 kHz) four-hydrophone 360° directional array mounted on a V-fin depressor. The VR-28 receiver was not capable of receiving simultaneous ultrasonic signals from multiple tags, so a 15-min rotation between each transmitter was adopted throughout to collect concurrent data sets for pairs of tunas. The Vemco ultrasonic transmitters (Models V16p: 50 kHz, 1000 psi and V22p: 34kHz, 1000 psi) were equipped with pressure sensors, and

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telemetered data on fish depth and direction, relative to that of the bow hydrophone, within the hydrophone array mounted to the V-fin.

Vemco V-16P (50 kHz) tags were surgically implanted in the peritoneal cavities of skipjack and V-22P (34 kHz) tags into those of bigeye tunas. Three bigeye and two skipjack tunas received acoustic tags in 2002 and six bigeye and two skipjack received acoustic tags in 2003. Fish with acoustic tags were monitored and data collected with the VR-28 receiver for about 48 h in 2002 and for about 24 h in 2003, beginning 24 h or more after the fish had been tagged and released to avoid collection of data for any abnormal behavior as a consequence of tagging.

During each set of telemetry observations the relative orientation and movements of the schools making up the aggregation were monitored through scanning sonar and echosounder imaging, from which selected images were recorded with a digital camera. The sonar was used for observing the aggregation's bearing, range, size, and behavior. The echosounder was used to observe the aggregation's vertical distribution and behavior, to identify presence or absence of bigeye tunas, and to monitor the diel vertical migrations of the deep scattering layer (DSL). In addition, a hard-wired underwater color video camera connected to a monitor and VCR recorder was suspended horizontally at a depth of 20 m under the vessel. The video images provided additional confirmation of species identification and behavior.

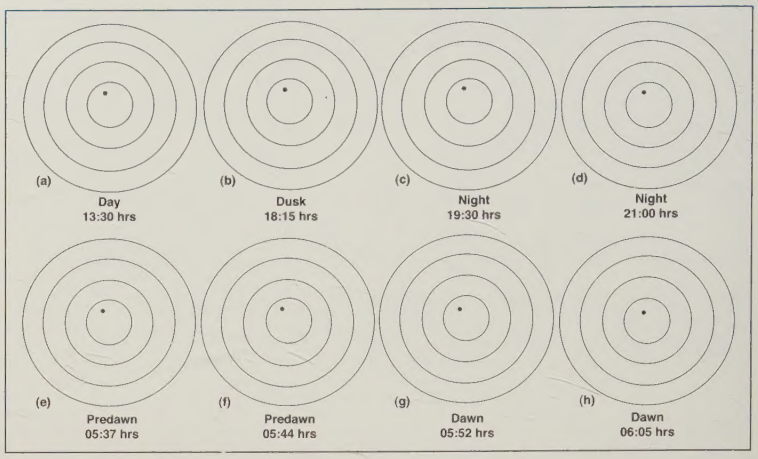

Figure 2. Images from a side-scan sonar of a large multi-species aggregation of bigeye and skipjack associated with a moored buoy 7 - 9 May 2002. Center of each image is the position of the sonar dome on the hull of the vessel. Concentric rings represent 150-ft (46-m) increments. Black dot indicates position of buoy relative to the vessel. Each image was taken during the ultrasonic telemetry of the bigeye and skipjack behavior described in the text. a) Daytime aggregation, 13:30 hrs 7 May, b) Dusk aggregation, 18:15 hrs 7 May, c) Night aggregation, 19:30 hrs 7 May, d) Night aggregation, 21:00 hrs 8 May, e) Predawn aggregation, 05:37 hrs 9 May, f) Predawn aggregation, 05:44 hrs 9 May, g) Dawn aggregation, 05:52 hrs 9 May, h) Dawn aggregation, 06:05 hrs 9 May.

Four sets of observations, each consisting of the concurrent monitoring of pairs of skipjack and/or bigeye with implanted acoustic or archival tags, were conducted. The pairs of acoustically tagged bigeye and skipjack, and also the entire aggregations, were primarily upcurrent of the moored buoy (Figures 1 and 2) and downcurrent of the drifting vessel during the day. At night the aggregations were observed to be more diffuse (Figure 2), and the fish were feeding on organisms of the deep scattering layer (DSL). The aggregations returned to positions upcurrent of the buoy or downcurrent of the drifting vessel at dawn, commonly "breezing" at the surface within cohesive monospecific schools. The estimated size of this multi-species aggregation, consisting primarily of bigeye and skipjack, with some yellowfin tuna (*Thunnus albacares*) as well, based on the sonar imaging and visual observations, was estimated as >100 metric tons.

The bigeye and skipjack had concurrent changes in depth records, occupying significantly greater mean depths at night than during the day, in most cases (Figure 3). Both species remained primarily above 30 m depth and 20° C. Both fish showed an average range in depth of 20 m during each 15-min sampling interval, and minimum and maximum depths were comparable for both fish during day and night. When associated with a moored buoy, bigeye depth distributions were greater during the day and night than those of skipjack (Figure 3), but bigeye depth distributions were less during the day and night than those of skipjack when associated with the drifting vessel. Simultaneous depth records of a large and a small bigeye with archival tags associated with a moored buoy also indicated diel changes in depth. The mean depth at night was significantly less than during the day for the larger bigeye, but the opposite was the case for the smaller bigeye. The mean depths during the day and night were significantly greater for the larger bigeye than for the smaller ones.

A plausible explanation for the greater depths at night than during the day in this study is the nighttime vertical distribution of the DSL in conjunction with the feeding behavior of the tunas while associated with the moored buoys and the drifting vessel in the study area. Recently ingested organisms of the DSL, consisting mostly of gonostomatids, myctophids, and cephalopods, in order of occurrence, were present in stomachs of bigeye and skipjack examined from about 2000 h to 0400 h, whereas throughout the day most of the stomachs examined were relatively empty. Most previous studies of the feeding habits of FAD-associated and unassociated tuna schools are potentially biased because most samples have come from commercial fishing vessels, which capture tunas primarily during the day. The apparent gastric evacuation rates by tunas of 6-8 h for cephalopods and probably small mesopelagic fishes, could lead to the conclusion that FAD-associated tunas are not feeding, although they are actually gorging themselves on DSL organisms at night.

Understanding the recruitment and residence dynamics of tuna species that form large multi-species aggregations near drifting FADs is important. Fishing for tropical tunas associated with

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PFRP Updates Research Priorities: Changes Form New Basis for 2006 RFPs

The Pelagic Fisheries Research Program has been operating for 10 years under research priorities established in a March 1992 workshop. Fisheries management concerns, governance arrangements, and the fisheries themselves have changed radically in the past 10 years. The ecosystem approach to fisheries has become the dominant paradigm for 21st century fisheries management. The Western and Central Pacific Fisheries Commission began operations in 2004, establishing a management regime to regulate the largest unregulated tuna fishery in the world. Surface fisheries for tropical tunas have expanded, pushing the total harvest in the western and central Pacific Ocean above 2 million metric tons.

A second workshop met November 16-18, 2005 in Honolulu immediately following the PFRP Principal Investigators meeting to update PFRP research priorities. A distinguished group of speakers from major tuna research and management institutions around the Pacific opened the workshop: Kitty Simonds, Executive Director, Western Pacific Regional Fishery management Council, Honolulu; Samuel Pooley, Director, Pacific Islands Fishery Science Center, Honolulu; Ziro Suzuki, Director, Pelagic Fisheries Resources Division, National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Shimizu, Japan; Richard B. Deriso, Chief Scientist, Tuna-Billfish Program, Inter-American Tropical Tuna Commission, La Jolla; John Hampton, Programme Manager, Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia.

Workshop participants divided themselves into four breakout sessions for "brainstorming sessions" around specific topics:

- Economics applied to the development of fishery management policy;
- Ecosystem integration—incidental catch and protected species, ecosystem delineation and indicators, oceanography, and modeling;
- Application of biology and life history studies to the development of fishery management policy;
- Informing fisheries management through understanding of fishing communities;
- The research ideas generated in the smaller groups were presented to the workshop plenary, discussed further, and then ranked. Each group identified priority research topics.

Some of the high ranking topics include:

- Economic modeling which explore management policy choices and their impacts on the fishing industry and target and non-target species abundance;

Invited speakers (l to r): John Hampton, Kitty Simonds, Sam Pooley, and Ziro Suzuki.

- Ecosystem impact of reduction of the abundance of specific tuna species, studies of movement on all scales through support of local regional and basin-scale tagging;
- Analysis of sources, distribution and cultural value of fish in fishing communities.

These new priorities are the basis for a request for research proposals to be circulated this month. A complete report of the workshop is available on the PFRP website http://www.soest.hawaii.edu/PFRP/.

On the closing day of the Workshop, November 18, the U.S. Senate ratified both the Convention for the Strengthening of the Inter-American Tropical Tuna Commission established by the 1949 Convention between the U.S. and the Republic of Costa Rica, with Annexes, (the "Antigua Convention") and the Convention on the Conservation and Management of the Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, with Annexes (the "WCPF Convention"). The U.S. is thus a full participant in both organizations that will manage fisheries tuna and tuna-like species in the Pacific Ocean Basin in the 21st century. The new research priorities of the PFRP will contribute to the scientific support base for this new regime.

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2005 PFRP Principal Investigators Project Presentation Updates and Research Priorities Workshop Guest Speakers

The website URLs following the project titles provide online access to PowerPoint presentations (in PDF format) where available; if PDFs are not available, please contact the P.I. For more information visit the Pelagic Fisheries Research Project online at http://www.soest.hawaii.edu/PFRP.

2005 PFRP Principal Investigators Workshop

Naresh Pradhan and PingSun Leung, UH
A Multi-objective Programming Model for Optimal Fleet Efforts: Incorporating Sea Turtle Interactions with Spatial and Seasonal Considerations in Hawaii Longline Fishery

Junning Cai, PingSun Leung, Minling Pan and Sam Pooley, UH, NMFS-PIFSC
Linkage of Fisheries Sectors to Hawaii's Economy and Economic Impacts of Longline Fishing Regulations
http://www.soest.hawaii.edu/PFRP/nov05mtg/cai_linkage.pdf (186 KB)

Shichao Li and Minling Pan, UH, NMFS-PIFSC
Rethinking Time/Area Closure for Turtle Take Reductions—Tradeoff between Turtle Take Reductions and Economic Impacts

Quang Nguyen and Minling Pan, UH, NMFS-PIFSC
Technology Changes and the Impact in Fishing Capacity in the Hawaii Longline Fleet

Minling Pan and Adam Griesemer, NMFS-PIFSC, UH
Economic Valuation of Fishing Tournaments in Hawaii

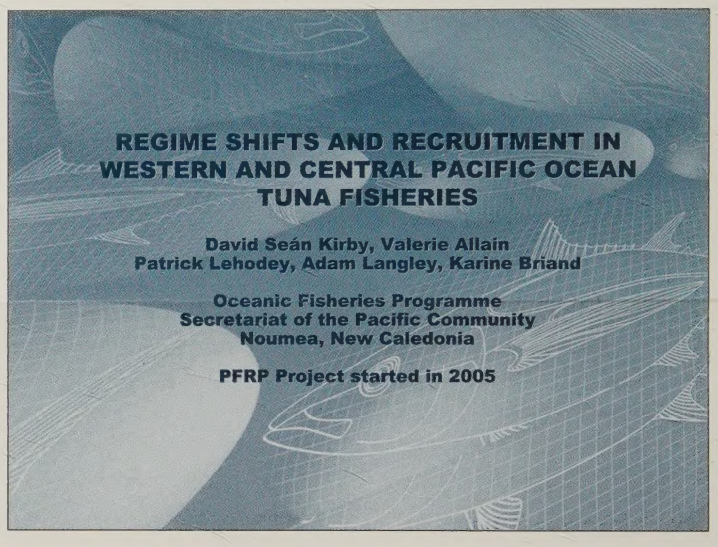
Judith Amesbury, Micronesian Archaeological Research Services (MARS)
Archaeological and Historical Data on Pelagic Fisheries in Guam and the Northern Mariana Islands
http://www.soest.hawaii.edu/PFRP/nov05mtg/amesbury_archaeological.pdf (1.4 MB)

Edward Glazier, Impact Assessment, Inc.
Human Dimensions Analysis of Hawaii's Ika-Shibi Fishery
http://www.soest.hawaii.edu/PFRP/nov05mtg/glazier_ika_shibi.pdf (2.6 MB)

Amy Gough and Stewart Allen, NMFS-PIFSC
Hawaii-Based Longline Fishermens, Perceptions of and Experiences with the Observer Program
http://www.soest.hawaii.edu/PFRP/nov05mtg/gough_observer_program.pdf (521 KB)

Selina Heppell and Molly Lutcavage, OSU, UNH
The Pacific-Atlantic Sea Turtle Assessment Project: Objectives and Progress
http://www.soest.hawaii.edu/PFRP/nov05mtg/heppell_lutcavage_turtle.pdf (1.3 MB)

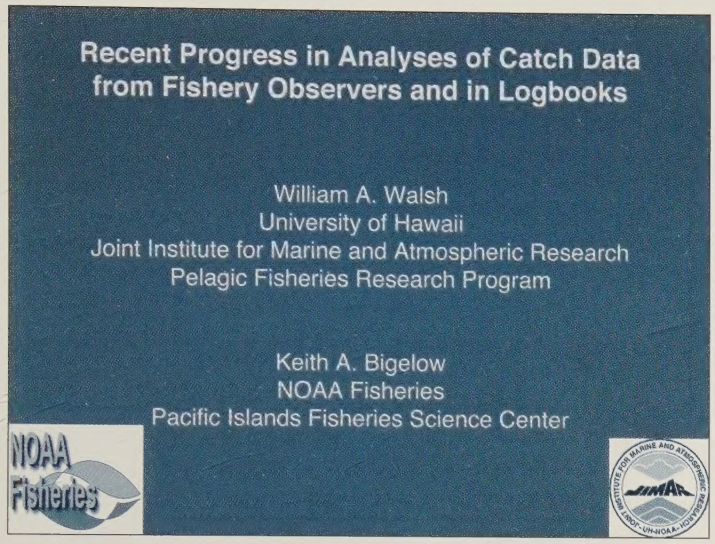
David Kirby, SPC
Preliminary Simulations of Western Pacific Leatherback Movements using an Individual-based Model
http://www.soest.hawaii.edu/PFRP/nov05mtg/kirby_turtles.pdf (132 KB)


REGIME SHIFTS AND RECRUITMENT IN WESTERN AND CENTRAL PACIFIC OCEAN TUNA FISHERIES
David Seán Kirby, Valerie Allain
Patrick Lehodey, Adam Langley, Karine Briand
Oceanic Fisheries Programme
Secretariat of the Pacific Community
Noumea, New Caledonia
PFRP Project started in 2005

Mark Maunder, I-ATTC
Lessons from an Adventure into Protected Species Modeling
http://www.soest.hawaii.edu/PFRP/nov05mtg/maunder.pdf (125 KB)

Jeremy Bisson and David Duffy, UH
How much Bait would an Albatross take if an Albatross could take Bait?
http://www.soest.hawaii.edu/PFRP/nov05mtg/bisson_albatross.pdf (1.3 MB)

Reka Domokos, NMFS-PIFSC
Oceanographic Influences on Catch Rates in the American Samoa Longline Fishery
http://www.soest.hawaii.edu/PFRP/nov05mtg/domokos_albacore_asamoa.pdf (5.2 MB)


Recent Progress in Analyses of Catch Data
from Fishery Observers and in Logbooks
William A. Walsh
University of Hawaii
Joint Institute for Marine and Atmospheric Research
Pelagic Fisheries Research Program
Keith A. Bigelow
NOAA Fisheries
Pacific Islands Fisheries Science Center
NOAA Fisheries

Evan Howell, NMFS-PIFSC
HL Fishery at 30N for Bigeye Tuna: Integrating Environmental, Longline, TDR, and PAT Tag Data

William A. Walsh, NMFS-PIFSC
Recent Progress in Analyses of Catch Data from Fishery Observers and in Logbooks
http://www.soest.hawaii.edu/PFRP/nov05mtg/walsh_catch_data.pdf (389 KB)

Robert Olson, Brittany Graham, Felipe Galván-Magaña, Brian Popp, Valerie Allain and Brian Fry, I-ATTC, UH, CICIMAR, UH, SPC, LSU

(continued on page 6)

Pelagic Fisheries Research Program Newsletter
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UPCOMING EVENTS

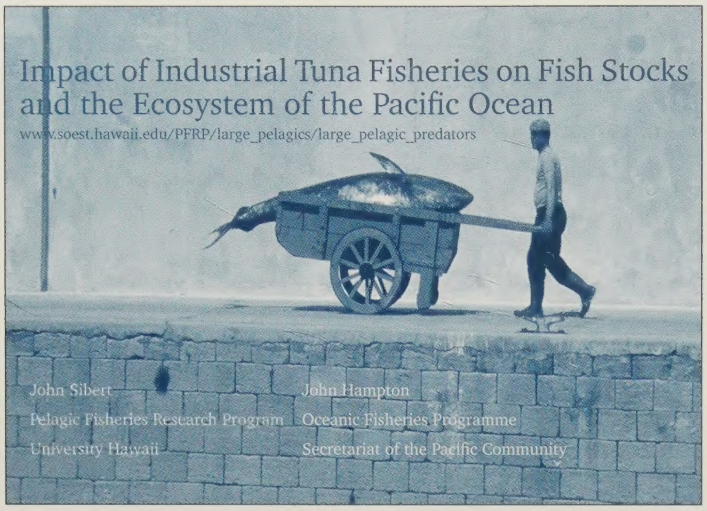
European and Caspian Sea Regional Sustainable Seafood Summit
January 27-28, 2006
Contact: World Ocean Network Office at meeting@nausicaa.fr
Online information: http://www.worldoceannetwork.org/

The 3rd International World Ocean Network Meeting
January 28-February 2, 2006
Boulogne sur Mer, France
Contact: World Ocean Network Office at meeting@nausicaa.fr
Online information: http://www.worldoceannetwork.org/

Sharing the Fish '06 Conference: Allocation Issues in Fisheries Management
February 26-March 2, 2006
Esplanade Hotel, Fremantle, Australia
Contact: Conference Secretariat Office at info5@eventedge.com.au
Online information: http://www.fishallocation.com/about/index.html

57th Tuna Conference, What Do Large Pelagics Want? Motivations for Migration
May 22-25, 2006
UCLA Lake Arrowhead Conference Center, California
Contact: Co-chairs Russ Vetter and Suzy Kohin at tuna conference@noaa.gov
Online information: http://swfsc.ucsd.edu/tunaconf.html

International Institute for Fisheries Economics and Trade (IIFET)—2006 Biennial Conference
July 11-14, 2006
University of Portsmouth (UK)
Contact: nicola.waterman@port.ac.uk
Online information: http://www.port.ac.uk/research/cemare/


Impact of Industrial Tuna Fisheries on Fish Stocks and the Ecosystem of the Pacific Ocean
www.soest.hawaii.edu/PFRP/large_pelagics/large_pelagic_predators
John Sibert
Pelagic Fisheries Research Program
University Hawaii
John Hampton
Oceanic Fisheries Programme
Secretariat of the Pacific Community

Seeking Trophic Clarity: Linking Stable Isotopes and Stomach Contents in the Pelagic Eastern Pacific Ocean
http://www.soest.hawaii.edu/PFRP/nov05mtg/olson_trophic_clarity.pdf (2.3 MB)

Valerie Allain, Brian Fry, Robert Olson, Felipe Galván-Magaña, and Brian Popp, SPC, LSU, I-ATTC, CICIMAR, UH
Diet of Tunas in the Pacific Ocean
http://www.soest.hawaii.edu/PFRP/nov05mtg/allain_tuna_diet.pdf (1.4 MB)

Brian Popp, UH
Insight into Tuna Trophic Level and Physiology from Compound-Specific Nitrogen Isotope Analysis of Proteinaceous Amino Acids
http://www.soest.hawaii.edu/PFRP/nov05mtg/popp_amino_acid.pdf (1.7 MB)

Brittany Graham, Brian Fry, Brian Popp, Valerie Allain, Robert Olson and Felipe Galván-Magaña, UH, LSU, UH, SPC, I-ATTC, CICIMAR
Isotope Biogeography: A Novel Approach to Studying Pelagic Predators in the Equatorial Pacific Ocean
http://www.soest.hawaii.edu/PFRP/nov05mtg/graham_biogeography.pdf (2.7 MB)

John Sibert and John Hampton, UH, SPC
Impact of Industrial Tuna Fisheries on Fish Stocks and the Ecosystem of the Pacific Ocean
http://www.soest.hawaii.edu/PFRP/nov05mtg/sibert_impact_fisheries.pdf (5 MB)

David Kirby, Patrick Lehodey, Valerie Allain, Adam Langley, and Karine Briand, SPC
Regime Shifts and Recruitment in Western & Central Pacific Ocean Tuna Fisheries
http://www.soest.hawaii.edu/PFRP/nov05mtg/kirby_regime_shifts.pdf (485 KB)

Patrick Lehodey, SPC
Multi-species Populations Modeling with Seapodym
http://www.soest.hawaii.edu/PFRP/nov05mtg/lehodey_seapodym.pdf (2.8 MB)

Inna Senina and John Sibert, UH
Progress in Parameter Estimation for Spatial Population and Ecosystem Dynamics Model (Seapodym) applied to Pacific Skipjack
http://www.soest.hawaii.edu/PFRP/nov05mtg/PESeapodym1.pdf (585 KB)

John Sibert and Johnoel Ancheta, UH
Status of Electronic Tag Data Repository
http://www.soest.hawaii.edu/PFRP/nov05mtg/sibert_ancheta_data_repository.pdf (65 KB)

Anders Nielsen, UH
From Light Measurements to Most Probable Track
http://www.soest.hawaii.edu/PFRP/nov05mtg/nielsen_light_measurements.pdf (500 KB)

Laurent Dagorn, IRD
News from the European Project FADIO in the Indian Ocean: Preliminary Results on Behavior of Fish around Drifting FADs and Prototypes of Instrumented Buoys
http://www.soest.hawaii.edu/PFRP/nov05mtg/dagorn_fadio.pdf (1 MB)

Kim Holland, UH
Overview of Hawaii FAD Related Research
http://www.soest.hawaii.edu/PFRP/nov05mtg/holland_fad_research.pdf (2.7 MB)

Carl Meyer and Kim Holland, UH
Status of Web-Based Fish Track Archive
http://www.soest.hawaii.edu/PFRP/nov05mtg/meyer_database.pdf (867 KB)

Mark Maunder, I-ATTC
Stock Assessment Modeling Workshop
http://www.soest.hawaii.edu/PFRP/nov05mtg/maunder_stock_assessment_workshop.pdf (59 KB)

Research Priorities Workshop Guest Speakers

Kitty Simonds, Western Pacific Regional Fishery Management Council (WestPac Council)
Lines on the Ocean: Managing U.S. Pelagic Fisheries in the Pacific in the 21st Century

http://www.soest.hawaii.edu/PFRP/nov05mtg/simonds.pdf (6.5 MB)

Sam Pooley, NMFS-PIFSC
NOAA Fisheries Research and Mandates Concerning Pelagic Fisheries in the Pacific
http://www.soest.hawaii.edu/PFRP/nov05mtg/pooley.pdf (1.7 MB)

Ziro Suzuki, NRIFSF, Shimizu
Pacific Bluefin Tuna, Treasure Box for Scientific Studies or Pandora's Box?
http://www.soest.hawaii.edu/PFRP/nov05mtg/suzuki_bluefin.pdf (1.9 MB)

Rick Deriso, I-ATTC
Some Research Ideas to Support Management of ETP Tuna and Billfish Fisheries
http://www.soest.hawaii.edu/PFRP/nov05mtg/deriso.pdf (26 KB)

John Hampton, SPC
Oceanic Fisheries Programme Strategic Plan 2006-2008
http://www.soest.hawaii.edu/PFRP/nov05mtg/hampton.pdf (627 KB)

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U.S. Pacific Islands Offshore Fisheries Benefit From Change to Place-Based Management

The Western Pacific Regional Fishery Management Council has approved a change from species-based to place-based management of offshore fisheries in the U.S. Pacific islands. Under the change, the four existing fishery management plans (FMPs) for bottomfish, crustaceans, precious corals and coral reef resources in federal waters (generally three to 200 miles offshore) of the U.S. Pacific islands would be restructured into four place-based fishery ecosystem plans (FEPs):

- Mariana Archipelago FEP (to include Guam and Northern Mariana Islands);
- Hawaii Archipelago FEP (to include both the main and Northwestern Hawaiian Islands, including Midway Island);
- American Samoa Archipelago FEP; and
- Pacific Islands Remote Island Areas FEP (to include the islands and atolls of Baker, Howland, Jarvis, Johnston, Palmyra, Wake and Kingman Reef).

The existing Pelagic FMP for the Western Pacific Region would become a Pacific Pelagic FEP. This structural change will allow the Council in the future to incorporate more ecosystem-based principles into the management of fisheries in the federal waters (generally three to 200 miles offshore) of the U.S. Pacific islands. No new regulations would be implemented at this time.

The "ecosystem-based" approach to fishery management has been promoted since 1986 by policymakers, fishery management agencies and environmentalists worldwide, including the President's Commission on Ocean Policy, Pew Ocean Commission, NOAA and the UN Food and Agriculture Organization, among others. The Council adopted the objectives, boundaries, management unit species designation, structure of the Council's advisory groups, and regional/international coordination and community participation of the FEPs. Council staff will work with the National Marine Fisheries Service (NMFS) and local resource management agency staff to ensure that the draft FEPs are accurate and clear and respond to public comments, as appropriate, before transmitting the FEPs to NMFS for approval by the Secretary of Commerce.

For more information, contact the Council at (808) 522-8220, (808) 522-8226 (fax), info.wpcouncil@noaa.gov or www.wpcouncil.org. The Western Pacific Regional Fishery Management Council is the policy-making agency for fisheries management in federal waters (three to 200 miles offshore) of the U.S. Pacific islands.

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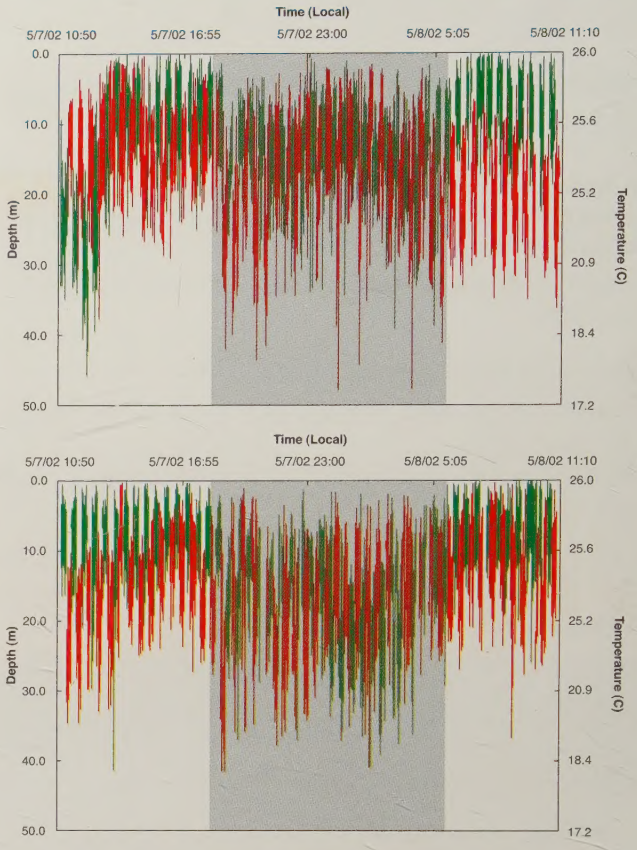
Behavior of Bigeye and Skipjack (continued from page 2)

FADs by purse-seine vessels has become extremely efficient, and fishing techniques are continually evolving to further increase efficiency. There is a need to elucidate the diel differences in the behavior of bigeye and skipjack within large multi-species aggregations associated with drifting FADs. Such research may reveal horizontal and/or vertical separation between monospecific schools of these species, possibly providing a way of reducing the purse-seine catch of bigeye while still capturing the schools of skipjack associated with drifting FADs.

The results of the research described are an excerpt from the publication: Schaefer, K.M. and D.W. Fuller. 2005. Behavior of bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*) tunas within aggregations associated with floating objects in the equatorial eastern Pacific. *Marine Biology* 146: 781-792.

PFRP

Kurt Schaefer and Daniel Fuller are tuna biologists with the Inter-American Tropical Tuna Commission



(right) Figure 3. Concurrent depth records from ultrasonic telemetry for a 90 cm bigeye (red) and 61 cm skipjack (green) within a large multi-species aggregation associated with a moored buoy, during a 48-h period in May 2002 divided into two 24-h windows. Grey panels indicate night time.

PFRP Pelagic Fisheries Research Program

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